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on

VACUUM ULTRAVIOLET RADIATION AND SOLID STATE PHYSICS

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#1

submitted by
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"Vacuum Ultraviolet Radiation and Solid State Physics"

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This NASA grant concerns itself primarily with vacuum ultraviolet radiation and its interactions with solid materials. During this report period it became obvious that government economies might well lead to a curtailment of funds available under this grant. Because of the uncertainties involved in this question, some contraction of our scientific group together with their supporting members was initiated. This required that some of the phases of the work done under this grant previously have now either been terminated or drastically reduced. The various activities done under the auspices of this grant will be described under the following headings.

1. Light Source and Detector Development of Vacuum Ultra-Violet Radiation

This material has been summarized in an abstract submitted to the American Physical Society Meetings at Pasadena, December 19 to 21, 1963; Bull. Am. Phys. Soc. 8, 610 (1963).

At the present time this activity is dormant and will only be revived if additional funds become available in the future.

2. Plasmon Radiation Excited in Thin Films by 50 KV Electrons

This material also has been submitted to the December 1963 Pasadena A.P.S. Meetings; Bull. Am. Phys. Soc. 8, 621 (1963).

At the present time it is being attempted to measure transition radiation from aluminum films, as dispersed on our normal incidence vacuum spectrograph. In the course of the last few months, it has become apparent that higher electron beam currents than used previously are required and that the highest sensitivity photographic emulsion must be used. Both of these factors should make it possible to detect this transition radiation as a well defined peak in the neighborhood of 800Å. We are very much encouraged that Dr. Arakawa's group of the Health Physics Division at the Oak Ridge National Laboratory has reported initial success in the observation of this transition radiation. Thus, we feel reasonably confident that our group should be able to observe this effect at the USC Laboratories. It need not be pointed out here that this is a new phenomenon, and the observation of spectrally resolved transition radiation should contribute materially to our understanding of the interaction of charged particles with electron plasmas in solids.

3. Photon Flux Measurements in the Vacuum Ultraviolet

An abstract on this work was submitted to the December

1963 Pasadena A.P.S. Meetings; Bull. Am. Phys. Soc. 8, 610 (1963).

Using an energy sensitive detector such as a blackened thermocouple or thermistor, one can compare directly the energy flux in the desired vacuum ultraviolet spectral range to that of a standard light in the visible range. The accuracy of such measurements is given by the ratio of the noise equivalent power of the detector to the incident power. At present the most accurate energy flux measurements can be made with a thermopile. The measured noise equivalent power of the thermocouple system we have used is about 3×10^{-9} watts for a bandwidth of 1 cps while the energy flux available from the brightest spectral line in the vacuum ultraviolet with a 5Å bandwidth is only on the order of 50 times as great. This gives an accuracy of 2% at a limited number of wavelengths. The accuracy can be increased by either increasing source intensities or decreasing the noise equivalent power of the detecting system. For the existing thermopile when operated at room temperature there is an absolute lower limit of about 3×10^{-10} watts in a 1 cps bandwidth due to Johnson noise and current noise. The apparatus described in this report was designed to improve appreciably the accuracy of absolute photon flux measurements by both increasing the source intensity and decreasing the noise equivalent power of the detector system.

4. Time-Delayed Fluorescence from Excited Ionic States of CO, CO_2, O_2, and N_2O

This material was partly supported by our NASA grant because the research involved photon flux measurements, a subject which is part of our NASA-sponsored program; Bull. Am. Phys. Soc. 9, 183 (1964).

Because of the serious cut-back in available funds this phase of our NASA-sponsored research has been in part shifted over to the work supported by ONR.

5. Vacuum Ultraviolet Photon Interactions with Surfaces kept in an Ultra-High Vacuum

The work described in the earlier status reports is being continued by E. I. Fisher, L. Whalley, and I. Fujita. We have introduced modifications in the metal gasket sealing techniques which should allow us to work in the 10^{-10} mm Hg range. In addition, the mechanical forepump has been replaced after bakeout by a chemical absorption pump (Trump). These techniques are the newest ones in use at one of the more experienced ultra-high vacuum laboratories, namely Livermore.

As soon as these mechanical changes have been tried out, sometime in the spring of 1964, it is hoped to initiate in the near future the proposed research on the reflectivities of a clean Barium surface in vacua of the order of 10^{-10} mm Hg.

Since the ultra-high vacuum chamber will use initially sapphire windows which do not transmit radiation of

wavelengths shorter than 1600Å, our initial work on optical constants will have to concern itself with those materials (of which Barium is one) which exhibit most of their significant optical properties at wavelengths longer than the transmission of sapphire. However, design studies are now actively underway to build a second ultra-high vacuum chamber in which optical constants can be studied over a very wide spectral range, from 10,000Å (~1 ev) down to 500Å (~20 ev). Of course this requires that the present ultra-high vacuum system be converted into a Seya monochromator and that the radiation from this monochromator can pass through an exit slit and without intervening windows into the new ultra-high vacuum chamber. The rapidity with which this study can be translated from paper design into an operating instrument will depend on the availability of new NASA funds later in 1964.

6. Photoelectric Yields, Transmissivities, and Reflectivities at Grazing Incidence

This work is being carried out by Mr. J. E. Rudisill and Mr. A. L. Morse. During this period the spectrum from a low pressure spark source through a ceramic capillary has been analyzed with the Vodar grazing incidence monochromator. Wavelengths of various strong lines between 100Å and 1000Å have been recorded and subjected to a preliminary identification. In addition, a reflectivity chamber has been installed and subjected to preliminary tests. At the time of

this writing initial reflectivity results on aluminum films are being taken at various angles.

This chamber also includes the capability of positioning the reflecting surface such that this surface is either parallel to the electric vector of the incident radiation or nearly perpendicular to this same electric vector. This allows us to carry out measurements which take into account so-called polarizabion effects, a phenomenon which has never been investigated in the region of the extreme vacuum ultraviolet.

This same reflectivity chamber will also lend itself to measurements of the photoelectric yields in this wavelength region. These yields again must be studied with a knowledge of the polarization effects. Beyond this, the photoelectric yields deserve more detailed investigation because of serious discrepancies between values reported at very short wavelengths (in the neighborhood of 100Å) by the Russian group under Lukirskii at Leningrad and Weissler's group at somewhat longer wavelengths (above 400Å).

Finally, this Vodar grazing incidence monochromator can be coupled to a large aluminum vacuum chamber, 18" I.D., which will allow the measurement of grazing incidence efficiencies in this short wavelength region. As far as this writer is concerned, there exists no apparatus anywhere which allows the measurement as a function of wavelength in the grazing incidence region between 1000 and 100Å of the ratio of the incident light intensity to that in the first order. It is

planned to study grazing incidence efficiencies for a variety of gratings, both blazed and unblazed and lightly ruled.

7. Summary

In spite of the re-orientation required due to a cut-back in funds during the six month period covered by this report, considerable progress has been made. It is hoped that future NASA support will provide increased momentum to the research activities presently under way. A new grant proposal for the fiscal year starting July 1, 1964 is in the process of being prepared.

With the described research facilities either operating or very close to being in operating condition, it is suggested that other NASA investigators contact the underwigned if these facilities may prove to be of immediate interest.

We make particular reference to our capability of measuring grating efficiencies at very short wavelengths.

25 copies respectfully submitted,

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